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SURVEY OF 1988 BUILDING PRACTICES FOR SINGLE-FAMILY HOUSES

May, 1990

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and Conservation

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EXECUTIVE SUMMARY

The Montana Department of Natural Resources and Conservation (DNRC) surveyed Montana homebuilders and contractors in March, 1989, to determine the levels of insulation and types of components used in building Montana houses during 1988.

A similar, but less detailed survey was completed in 1987 to assess the most common building practices used by builders in 1986. Although the 1986 and 1988 surveys are not precisely comparable, it appears that for Montana as a whole, houses built in 1988 are better insulated than houses built in 1986. When the results are further separated into their eastern and western subgroups, it is evident that the increase in the market penetration of energy-efficient components has occurred almost entirely in the eastern half of the state where the use of such components was, in prior years, not as frequent as in the west. DNRC judged the increase in market penetration on the basis of the number of builders approximating the Northwest Power Planning Council's Model Conservation Standards (MCS) for walls, ceilings and windows. Comparison of the two surveys showed that eastern Montana had an average 73 percent increase in the number of surveyed builders approximating the MCS standard for walls, ceilings and windows, while western Montana had an average 13 percent increase.

The 1988 survey was designed as a two-part questionnaire. The first part of the questionnaire asked builders to describe the last electrically-heated house they built in 1988, and the second part of the questionnaire asked for a description of the last non-electrically-heated house they built in 1988. This survey allowed DNRC to determine the current practice insulation level of various components as a function of heating fuel type. Since electricity is more costly per Btu of delivered heat than natural

gas, DNRC expected that electrically-heated houses would be better insulated than gas-heated houses.

Gas was the only non-electric heating source identified by survey respondents who used non-electric heating in new houses built for year-round occupation. Of the 97 builders responding to the 1988 survey, 43 built only gas-heated houses, 34 built only electrically-heated houses, and 20 built both gas-heated and electrically-heated houses; Montana builders built a median of two houses in 1988 with a range from 1 to 31 houses (the median is that number for which there are an equal number of responses both above and below).

Builders who completed the survey account for 376, or 24 percent, of the 1,580 houses built in Montana during 1988, exclusive of government-built houses on Indian reservations. Since the survey captured a large percentage of the houses built in 1988, DNRC believes that the survey responses represent the current residential construction practice in 1988.

Of the 376 new houses represented in the survey, 66 percent were gas-heated and 34 percent were electrically-heated. In western Montana 65 percent of the 307 survey houses were gas-heated, while in eastern Montana 71 percent of the 69 survey houses were heated with gas. Western Montana is defined here as the area of the state west of a line drawn between Kalispell and Bozeman.

Weighting

Each builder described the last house, by fuel type, that he built in 1988. The builder's responses were then weighted by the number of houses of that fuel type that he reported constructing during 1988. Weighted responses provide a more accurate picture of current practice because the influence of builders on the statistics is directly proportional to the number of houses built. Builders who built only one or two houses would be over-

represented if the responses were not weighted. The practice of weighting builders' responses has been carried out throughout the analysis of the survey.

Median Insulation Levels

One way to summarize insulation levels (a second way, the "MCS Ranking" method of summary, is shown on page vi) is to show what was found to be the median R-values for the various components of houses built in 1988. When sample sizes are small and distributions are not normal, as is the case with the results of this survey, median values are most representative of the overall tendency of the responses. It should be noted that the median value for a group may not be a number from that group; for instance, when taking the median of two-fives and two-tens the median is found to be 7.5.

The following table shows the median insulation R-value for each major component of a house as reported by those responding to the 1988 survey. The results are separated by type of heating fuel. Further separation of results into eastern and western Montana groups is provided for walls and ceilings (east is designated "E," and west is designated "W").

Table I. Median Insulation R-Values by Major House Component

COMPONENT	ELECTRICALLY-HEATED	GAS-HEATED
Walls	22.5 (E-20, W-22.5)	19 (E-19, W-19)
Ceiling	38 (E-38, W-38)	38 (E-38, W-38)
Basement Wall	11	19
Crawlspace perimeter	11	11
Floor above crawlspace	30	30

NOTE: For medians shown in parenthesis, "E" indicates the median for eastern houses and "W" indicates the median for western houses.

The median values shown in the table are for components that are actually insulated. Uninsulated components are not included in the calculations. This can affect the assessment of the results. For example, even though the median basement wall insulation in gas-heated houses is greater than in electrically-heated houses, a smaller percentage of gas-heated houses with basements have basement wall insulation. For electrically-heated houses with basements, 75 percent have basement wall insulation, while only 61 percent of the gas-heated houses with basements have basement wall insulation.

The analysis of the survey results indicates that there is a statistically significant difference between the overall insulation levels used in electrically-heated houses when compared to those used in gas-heated houses; electrically-heated houses are better insulated. However, there is no statistically significant difference between the overall insulation levels found in eastern versus western Montana houses.

Glazing: The most commonly used glazing for Montana houses is standard double glazing, regardless of heating fuel type. Sixty-three percent of the electrically-heated houses and 69 percent of the gas-heated houses have this type of window. Better windows, primarily double-glazed low-E windows, account for the rest of the glazing used in new houses.

Air/vapor barriers & caulking: A greater percentage of electrically-heated houses, 44 percent, than gas-heated houses, 20 percent, have air/vapor barriers (AVBs) in ceilings, walls and floors. All other houses, as per HUD requirements, have AVBs only in the walls. In contrast, wiring, plumbing and other penetrations are caulked in only 45 percent of the electrically-heated houses, while they are caulked in 57 percent of the gas-heated houses.

A larger percentage of eastern houses than western houses have AVBs in the ceilings, walls and floors. Eastern houses also have the wiring and plumbing penetrations caulked more often than western houses. Thirty-five percent of eastern houses and 27 percent of western houses have AVBs in the ceilings, walls and floors. All of the eastern houses in the survey were caulked, compared to only 45 percent of the western houses. The purpose of installing an AVB and sealing penetrations is to reduce the infiltration of outside air into the house and to reduce the exfiltration of moist inside air into the house's structural components and insulation. When these measures are installed, DNRC strongly suggests that a mechanical ventilation system with fresh air ports be installed to exchange stale inside air with fresh outside air.

Mechanical ventilation: The most common form of mechanical ventilation is an exhaust fan in the kitchen and each bathroom with no fresh air make-up ports or inlets. Exhaust fans without fresh air inlets are installed in 77 percent of the electrically-heated houses and 94 percent of the gas-heated houses. Conversely, only 8 percent of the new houses statewide include fresh air inlets as part of their mechanical ventilation system. The failure to provide fresh air inlets in tightly sealed houses could result in indoor air pollution and a potentially serious long-term health risk to occupants.

Two types of mechanical ventilation systems allow for the entrance of fresh air into a house: 1) heat recovery ventilators (HRVs), and 2) exhaust fans with fresh air ports or inlets. Either system is acceptable in a tightly sealed house. Only 14 percent of eastern houses and 7 percent of western houses employ such systems. Worse yet, only 2 percent of the gas-heated houses include one of the two systems described above; a troublingly

small number given the high incidence of well-sealed gas-heated houses.

Heating system types and outside combustion air: Eighty-three percent of electrically-heated houses use either baseboard or wall-mounted heaters. Eighty-five percent of gas-heated houses use high efficiency furnaces with annual fuel utilization efficiencies (AFUEs) of 80 percent or greater. Outside combustion air is supplied to the furnaces in 83 percent of eastern gas-heated houses and 99 percent of western gas-heated houses. However, only 37 percent of eastern houses responded to this question whereas 71 percent of western houses responded. The low eastern response may indicate a lack of understanding in regard to this important component.

Wood burning devices: Statewide, 31 percent of new houses have wood burning devices. Wood burning devices of some sort exist in 47 percent of the new electrically-heated houses and 23 percent of the new gas-heated houses. Since electricity is more expensive for heating than natural gas, the large percentage of electrically-heated houses with wood burning devices is not surprising. Wood burners were installed in 25 percent of eastern Montana houses and in 32 percent of western Montana houses.

MCS Ranking: For the purpose of quantifying the insulation levels installed in different types of Montana houses, DNRC has devised an "MCS Ranking" that was used to rate the components in each house in terms of their approximation to one of three standards: "less than HUD", HUD, and MCS. The "less than HUD" level is defined as that level of construction that does not meet the Minimum Property Standards of the United States Department of Housing and Urban Development (HUD), while the HUD level is that level meeting these standards. The MCS level applies when the Northwest Power Planning Council's Model Conservation Standards are met. Using this ranking method, each house was assessed on

the basis of 12 components. Three points were assigned for each component that met MCS standards, two points for each HUD component, and one point for components that did not meet HUD standards.

Responses to questions describing window glazing type and total wall R-value were weighted twice as much as responses to the other 10 questions. The purpose of the additional weight was to account for the larger effect of window glazing and wall R-value on a house's design heating load.

The points assigned to each of a house's components were then totaled and reduced to a ranking for that house. A house meeting the MCS standards would receive a ranking of 3.0, a house whose every component equaled the HUD standards would have a ranking of 2.0, while a house which met none of the HUD standards would receive a 1.0 ranking. Houses with components meeting differing standards received fractional rankings, 2.5 for instance. The rankings of all survey houses are presented in the following table where they are separated by heating-system type and geographic location.

Table II. Overall MCS Rankings of Houses in Montana by Heating System and Geographic Location

	ELECTRIC HEAT	GAS HEAT	ALL HOUSES
WESTERN MONTANA	2.32	2.15	2.20
EASTERN MONTANA	2.33	2.19	2.23
STATEWIDE	2.32	2.16	2.21

NOTES:
1) Ranking; 1.0 = "Less Than HUD," 2.0 = HUD, 3.0 = MCS.
2) Survey houses used in the MCS Ranking; 100 of 106 electric-west, 199 of 201 gas-west, 20 of 20 electric-east, and 49 of 49 gas-east. Statewide 368 of 376.

There is virtually no difference between the rankings of houses built in eastern Montana (2.23) and western Montana (2.20). Eastern electrically-heated houses, at 2.33, rank much the same as western electrically-heated houses at 2.32. Gas-heated houses, which ranked 2.19 for the east and 2.15 for the west, also received similar rankings. This table does show, however, that there is a substantive difference in the insulation levels and component types used in electrically-heated houses statewide, which rank 2.32, when compared to gas-heated houses statewide, which rank only 2.16. For all new houses built in 1988 the ranking is 2.21, indicating a statewide acceptance of at least some MCS components.

As was found in the 1986 survey, small-scale builders are more likely to build energy-efficient houses than large-scale builders. This is especially true in the western half of the state. Small-scale builders are defined as those building fewer than five houses in the survey year of 1988. Of the 97 builders returning the survey, 79 small builders statewide built 172 houses whose overall MCS Ranking is 2.33, compared to 15 large builders statewide whose 196 houses have an overall MCS Ranking of only 2.10. Three builders and eight houses were excluded from the MCS Ranking due to inadequate data.

Conclusion: Geographic location seems to have little bearing on the level of insulation incorporated into new houses by Montana's builders. Houses in eastern Montana were found to be insulated, overall, to approximately the same level as houses in the western part of the state. Of note is the fact that builders in the east tended to use insulation strategies different from those used in the west. While western builders used higher R-values in ceilings and walls, eastern builders more frequently utilized MCS-level air/vapor barriers, good sealing and caulking practices, and heat recovery ventilators.

Electrically-heated houses were found to be significantly better insulated than gas-heated houses. This is expected since the cost of electric heating is many times more expensive than the cost of gas heating. However, even the builders of gas-heated houses incorporated many energy-efficient components into their houses. Since MCS levels of energy-efficiency are not, at present, considered cost-effective for gas-heated houses, the decision to insulate gas-heated houses beyond HUD standards must be driven by other reasons. These reasons may include the desire to provide maximum occupant comfort and to protect against unforseen future fuel price increases.

The trend in insulation levels used in Montana's houses can be demonstrated by comparing the results of DNRC's 1986 and 1988 building practice surveys. The increase in the number of builders approximating the MCS standards between 1986 and 1988 has resulted in better insulated houses throughout Montana. Survey responses from western builders indicate that a minor increase in the use of energy-efficient components occurred in the west during this period. In contrast, responses from eastern builders indicate that the use of MCS-like components in the east increased, between 1986 and 1988, to the point that new eastern houses are now as energy-efficient as new western houses.

A substantial commitment in time and money has been invested throughout Montana to improve the energy-efficiency of houses in the state. The most notable of these efforts are the demonstration projects, workshops and incentive programs funded by the Bonneville Power Administration and instituted in western Montana. These efforts have resulted in the expectation that western Montana houses should be better-insulated than eastern Montana houses. The fact that this study finds eastern and western houses to be of similar energy-efficiency is contrary to what some expected.

INTRODUCTION

The Montana Department of Natural Resources and Conservation (DNRC) surveyed Montana homebuilders and contractors in March 1989. The purpose of the survey was to determine the insulation characteristics and component usage for single-family site-built houses constructed in 1988. DNRC completed a similar, but less detailed, survey in 1987 to determine the most common building practices used in 1986. Although the results of the two surveys are not directly comparable, the newer survey suggests that houses built in 1988 are somewhat better insulated than houses built in 1986.

The 1988 survey was designed as a two-part questionnaire. The first part of the questionnaire asked about the last electrically-heated house built in 1988 by the builder, and the second part of the survey asked about the builder's last non-electrically-heated house built in 1988. Selection of the "last house built" rather than the "average house built for the year" was intended to make the sample best represent overall construction practice. Since all non-electrically-heated houses built for year-round occupancy were heated by gas, these houses will be referred to as gas-heated houses. DNRC separated the houses by heating fuel type on the survey form to test the hypothesis that there is a difference in how electrically-heated and gas-heated houses are built and insulated. Appendix 1 contains a copy of the questionnaire.

DNRC also wanted to determine whether electrically-heated houses in western Montana are better insulated than electrically-heated houses in eastern Montana. Western Montana is defined here as the area west of a line drawn between Kalispell and Bozeman; see page 5 for details. The Bonneville Power Administration (BPA), whose service area is generally defined as western Montana, funds incentive programs such as the Super Good Cents (SGC) marketing

program. These programs are meant to encourage builders, through the direct payment of incentives, to meet or exceed the residential energy-efficiency requirements set forth in the Model Conservation Standards (MCS). The MCS were developed as energy-efficient building guidelines by the Northwest Power Planning Council. DNRC has found that houses in Montana built to the MCS standards use about 40 percent less space-heating electricity than houses built to the Minimum Property Standards of the United States Department of Housing and Urban Development (HUD).

The 1986 and 1988 surveys indicate that the majority of the site built houses constructed in Montana meet or exceed the component levels of insulation specified by HUD. This is not surprising in light of the fact that houses must have at least HUD levels of insulation in order to qualify for federally-insured mortgages such as those offered by the Federal Housing Administration (FHA).

The simplest way to represent the insulation levels required by MCS and HUD is to show minimum R-values for building components. Both standards allow some trade-offs in component insulation levels, but the minimums shown in Table 1 are generally representative of the two energy standards.

Table 1. HUD and MCS Minimum Component Insulation (Insulation R-Values)

	HUD	MCS
Walls	19	27
Ceilings	38	49
Floor Over Unheated Area	19	30
Basement Walls	11	19
Doors	5	5
Windows	Double-Glazed	Double-Glazed Low-E

The HUD standards require basement wall insulation only if the basement is to be used as occupied living space. The MCS standards require basement wall insulation if the basement is heated, otherwise, insulation is required only in the floor over the basement area.

Along with greater levels of insulation, MCS requires the use of an air/vapor barrier (AVB) in walls, ceilings, and floors. HUD requires an AVB only in the walls. A mechanical ventilation system with fresh air inlets is required in all MCS houses, while HUD houses generally include only bathroom exhaust fans.

DNRC's analysis of the responses to the 1988 survey indicates that there is a statistically significant difference in the overall insulation levels used in electrically-heated houses when they are compared to insulation levels used in gas-heated houses; electrically-heated houses are better insulated. However, there is no statistically significant difference between the overall insulation levels found in eastern versus western Montana houses.

SURVEY RESULTS

SURVEY RESPONSE

The mailing list for the survey was developed from lists of builders attending DNRC builder training workshops, from Montana phone books, and from the membership list of the Montana Homebuilders Association. Early in March of 1989, 448 survey forms were sent out. Completed surveys were returned by 113 people in the first mailing, and 51 surveys were returned as undeliverable. A second mailing, 296 survey forms, was sent out two weeks later. The second mailing yielded 80 completed survey forms.

Of the 193 completed surveys returned to DNRC, 97 were from builders or contractors who built one or more single-family houses in 1988. Eighty-six of the returned survey forms indicated the recipient did not build a house in 1988, and 10 of the returned surveys were not used because the data were considered incomplete or inappropriate for various reasons.

The 97 survey forms returned by homebuilders and used in compiling this data indicate that these builders built 376 single family houses during 1988. According to DNRC's estimates based on electrical permit records, 1,580 single family houses were built in Montana during 1988, exclusive of government-built houses on Indian reservations[1]. Given that 24 percent of the houses built in Montana are represented by this survey, DNRC believes that a reasonable estimate of 1988 residential construction practice can be drawn from the survey data.

EASTERN AND WESTERN MONTANA BUILDERS

Builders were classified as being from eastern Montana if the zip code on the returned survey form was from 59000 through 59599. Western builders are defined as those returning forms showing zip codes from 59600 through 59999. Western Montana homebuilders who build electrically-heated houses that meet or exceed the MCS requirements are eligible to receive incentive payments through BPA's Super Good Cents program as are eastern Montana builders whose houses are in the Montana Power Company service area.

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[1]Montana Department of Natural Resources and Conservation. Single Family Site-Built Housing Starts in 1988. P. Cartwright. Helena, Montana. October 1989.

Western Montana builders constructed 307 of the 376 houses in the survey sample while eastern Montana builders constructed 69 of the 376. Approximately one-third of the survey houses in both eastern and western Montana were electrically-heated (106 of 307 western houses, and 20 of 69 eastern houses). The geographic distribution of the houses in the 1988 survey as well as the distribution of all houses built statewide in 1988 is shown in Table 2.

Table 2. Distribution of Houses By Zip Code

ZIP CODE	MAJOR CITY	A # HOUSES IN SURVEY	B TOTAL HOUSING STARTS*	C COLUMN A DIVIDED BY COLUMN B
EAST:				
590	Livingston/Roundup	10	113	9%
591	Billings	32	123	26%
592	Glasgow/Sidney	0	9	0%
593	Miles City/Glendive	0	12	0%
594	Great Falls/Shelby	27	168	16%
595	Havre/Malta	0	15	0%
EAST TOTALS		69	440	16%
WEST:				
596	Helena/White Sulphur	19	149	13%
597	Butte/Bozeman/Dillon	61	252	24%
598	Missoula/Hamilton	158	374	42%
599	Kalispell/Libby	69	365	19%
WEST TOTALS		307	1,140	27%
STATEWIDE TOTALS		376	1,580	24%

* Beside the houses shown in column B, an additional 258 houses were built by the government on Indian reservations. Source: DNRC - Single Family Site-Built Housing Starts in 1988, P. Cartwright, October,1989.

In eastern Montana, 69 of the 440 houses built, or 16 percent, are represented in the survey. Western Montana is represented by 307 of the 1,140 houses built, or 27 percent of all houses. An additional 258 houses were built by the government on Indian reservations in 1988. These houses were not included in the survey because the construction standards were set by the government independently of market demand. The purpose of this paper is to identify current housing construction practice as a function of Montana consumer demand.

The median number of houses built by the 97 builders reporting statewide, regardless of the type of fuel used to heat the houses, was two. The median is that value for which there are an equal number of responses both above and below. Larger builders tended to be from the west and tended to build gas-heated houses. The largest of the 97 builders was from the west and built 31 gas-heated houses. For the 34 builders that built only electrically-heated houses the median number of houses built was 1.5, and ranged from 1 to 4 houses (it should be noted that the median value for a group may not be a number from that group; for example, when taking the median of two-fives and two-tens the median is found to be 7.5). For the 43 builders who built only gas-heated houses, the median number of houses built was two and the range was from 1 to 31 houses. For the 20 builders that built both electrically-heated and gas-heated houses during 1988,

the median number of houses per builder was two electrically-heated and two gas-heated houses for a median total of four houses per builder, with a range from 2 to 24 houses.

The median number of houses built by the 18 eastern builders was two and ranged from 1 to 24 houses. The median number of houses built by the 79 western builders was also two with a range from 1 to 31 houses. These figures show that the number of houses constructed per builder is similar at both ends of the state.

Table 3 categorizes builders by the number of houses built. The total number of builders, statewide, falling into each size category are shown. Further separation into eastern and western builders is provided for comparison of builder size by geographic location.

Table 3. Number of Builders by Number of Houses Built in 1988

# HOUSES	STATEWIDE N=97	EAST N=18	WEST N=79
1	27	5	22
2	25	5	20
3	19	2	17
4	11	3	8
5	4	1	3
6	2	0	2
7	1	1	0
12-15	4	0	4
23-31	4	1	3

FLOOR AREA OF HOUSES

The median floor area for all 1988 houses surveyed is 1,970 square feet. For electrically-heated houses, the median is 2,192 square feet. For gas-heated houses, the median is 1,900 square feet. The median floor area for eastern houses is 1,850 square feet, while the median floor area for western houses is 2,000 square feet.

Electrically-heated houses are, as a group, larger than gas-heated houses. The largest houses are eastern electrically-heated houses with a median size of 2,200 square feet, while the smallest houses are eastern gas-heated houses with a median size of 1,600 square feet.

WALL CONSTRUCTION

Builders were asked about the framing, cavity insulation and non-cavity insulation used in the walls of their houses. Table 4 lists wall framing types and the number of electrically-heated and gas-heated houses built using each type. The most common framing type, regardless of heating fuel type, is 2X6 studs at 16 inches on center. Further, 40 percent of the electrically-heated houses in the survey have advanced framing (2X6 studs at 24 inches on center, or 2X4 double walls) in contrast to only 15 percent of the gas-heated houses.

Table 4. Wall Framing Type

FRAMING TYPE	ELECTRICALLY-HEATED N=126	GAS-HEATED N=248
2X4, 16 inch o.c.	9	16
2X4, 24 inch o.c.	1	30
2X6, 16 inch o.c.	64	164
2X6, 24 inch o.c.	38	35
2X4, Double Wall	12	2
Other	2	1

The most common type of cavity insulation used, regardless of heating fuel type, is fiberglass batt; fully 80 percent of all Montana houses incorporated this material. Table 5 lists categories of cavity insulation and the number of houses in each category, separated by heating fuel type. Most of the walls in the "OTHER" category have sprayed urethane insulation.

Table 5. Cavity Insulation Type

TYPE	ELECTRICALLY-HEATED N=126	GAS-HEATED N=248
BATTS	111	188
BLOWN-IN	8	48
OTHER	7	12

WALL INSULATION

The median cavity R-value for both electrically-heated and gas-heated houses in the survey is 19. Fifty-six of 126 electrically-heated houses (44 percent) have non-cavity insulation, with a median R-value of 6.0, in addition to cavity

insulation. Seventy-four of 248 gas-heated houses (30 percent) have non-cavity insulation, with a median R-value of 5.0, in addition to cavity insulation. Non-cavity insulation typically consists of rigid-foam sheathing.

Tables 6 and 7 list total wall insulation R-values by fuel type and geographic location. The median total R-value for the walls of electrically-heated houses is 22.5. Eastern electrically-heated houses have a median total R-value of 20 while western houses have a median of 22.5. The median total R-value for the walls of gas-heated houses is 19 for both eastern and western gas-heated houses.

The walls in electrically-heated houses are better insulated than the walls in gas-heated houses. Sixty-three percent of the electrically-heated houses have walls with R-values in excess of the R-19 HUD standard while only 31 percent of the gas-heated houses exceed R-19. The difference between electrically-heated and gas-heated houses' wall insulation levels is statistically significant. Since electricity is more expensive than natural gas for heating, the greater amount of insulation in electrically-heated houses makes good economic sense.

Western Montana houses have slightly better-insulated walls than eastern houses. Forty-three percent of western walls are insulated to a level greater than R-19 compared to 33 percent of the eastern walls.

Table 6. Total Wall Insulation R-Values
Electrically-Heated Houses

WALL R-VALUE	STATE-WIDE N=126	EAST N=20	WEST N=106
10-11	3	1	2
12-14	0	0	0
16-18.5	4	1	3
19	40	8	32
20-22.5	24	1	23
22.6-25	19	0	19
26-27	14	5	9
28-33	8	0	8
34-38	3	0	3
Greater Than 38	11	4	7

Table 7. Total Wall Insulation R-Values
Gas-Heated Houses

WALL R-VALUE	STATE-WIDE N=248	EAST N=49	WEST N=199
10-11	4	2	2
12-14	4	0	4
16-18.5	36	1	35
19	128	33	95
20-22.5	45	3	42
22.6-25	11	4	7
26-27	15	5	10
28-33	3	0	3
34-38	0	0	0
Greater Than 38	2	1	1

CEILING INSULATION

The median ceiling R-value in eastern and western electrically-heated as well as eastern and western gas-heated houses is R-38. Over one-third of the houses built in the state substantially exceeded the R-38 HUD standard. Western Montana houses and electrically-heated houses were more likely to have ceiling

insulation levels above HUD standards than were eastern houses and gas-heated houses. Tables 8 and 9 list categories of ceiling R-values by fuel type and location.

Table 8. Ceiling R-Values
Electrically-Heated Houses

CEILING R-VALUE	STATE-WIDE N=126	EAST N=20	WEST N=106
Less Than 38	4	2	2
38-42	74	13	61
43-45	12	0	12
46-52	28	5	23
Greater Than 52	8	0	8

Table 9. Ceiling R-Values
Gas-Heated Houses

CEILING R-VALUE	STATE-WIDE N=248	EAST N=49	WEST N=199
Less Than 38	9	4	5
38-42	161	38	123
43-45	45	1	44
46-52	33	6	27
Greater Than 52	0	0	0

BASEMENTS

Seventy-seven percent of the houses built in Montana in 1988 were built with basements. Eastern builders incorporated basements into their houses 93 percent of the time compared to 73 percent for western builders.

Of the electrically-heated houses statewide, 75 percent have basements (eastern Montana 85 percent, western 73 percent), and for gas-heated houses statewide, 78 percent have basements (eastern Montana 96 percent, western 73 percent). Table 10 shows type of basements in the houses, separated by type of heating fuel.

Table 10. Types of Basements

TYPE OF BASEMENT	ELECTRICALLY-HEATED N=124	GAS-HEATED N=247
FULL BASEMENT	24	92
FULL DAYLIGHT BASEMENT (Some above-grade wall area)	52	57
PARTIAL BASEMENT	6	33
PARTIAL DAYLIGHT BASEMENT (Some above-grade wall area)	11	10
NO BASEMENT	31	55

The majority of the basements in the houses surveyed are heated. Of the 274 houses for which responses were obtained, 237 (87 percent) have heated basements. There was essentially no difference by fuel type (for electrically-heated houses, 76 out of 87, or 87 percent, have heated basements, and for gas-heated houses, 161 out of 187, or 86 percent, have heated basements).

Of the 11 electrically-heated houses reported with unheated basements, the floor above the basement was insulated in 9 out of the 10 cases where insulation use was reported. The median R-value of the floor insulation in these nine cases was 19. In addition, 12 out of the 76 electrically-heated houses with heated basements (16 percent) have insulation in the floor above the basement, with a median R-value of 11.

Of the 26 gas-heated houses reported with unheated basements, only one out of the 19 cases reporting insulation use had any insulation in the floor above the basement, in this case R-19. For the 161 gas-heated houses with heated basements, 7 out of the 151 cases reporting insulation use (5 percent) have insulation in the floor between the basement and the living area above. The median R-value for this insulation is 19.

BASEMENT WALL INSULATION

Most houses with basements have insulation on the basement walls, regardless of heating fuel type (185 out of the 282 reporting, or 66 percent). Because of the higher cost of electric heating, electrically-heated houses should be more likely to have basement wall insulation than gas-heated houses. This followed as 75 percent of the electrically-heated houses (66 of 88 reporting) versus 61 percent of the gas-heated houses (119 of 194 reporting) had basement wall insulation. Unexpectedly, the insulation used in electrically-heated houses has a lower total median R-value, 11, than gas-heated houses' total median R-value of 19.

In electrically-heated houses with basement wall insulation, insulation was more commonly used on the inside of the basement wall than on the outside. Ninety-two percent used only inside insulation, 3 percent used only outside insulation, and 5 percent used both inside and outside insulation. The median inside basement wall insulation R-value is 11, while the median outside insulation R-value is 5. The median total basement wall R-value is 11.

For gas-heated houses, inside basement wall insulation was used in all cases where the basement walls were insulated, and 5 percent of these used outside insulation in addition to the

inside insulation. The median inside basement wall insulation R-value is 19, while the median outside insulation R-value is 11. The median total wall R-value is 19.

Table 11 shows categories of total insulation R-values for basement walls and lists the number of houses in each category. The categories are further separated by heating fuel type. The builder of the four houses appearing in the "UNKNOWN R" category reported the use of inside basement wall insulation but did not report an R-value for the insulation.

Table 11. Basement Wall Insulation R-Values (Total)

BASEMENT WALL R	ELECTRICALLY-HEATED N=88	GAS-HEATED N=194
NO INSUL.	22	75
UNKNOWN R	0	4
---	--	--
5-6.5	1	3
8-10	2	3
11-13	34	41
14-19	20	54
Greater Than 19	9	14

BASEMENT SLAB INSULATION

Basement slab insulation is not common for either gas or electrically-heated houses. Of the 93 electrically-heated houses with basements, 80 responded to the question about basement slab insulation. Thirteen of the 80 houses reporting, or 16 percent, had insulated basement slabs. Of the 13 houses with insulated basement slabs, 7 have perimeter slab insulation with a median R-value of 15, and 6 houses have full-slab insulation with a median R-value of 10.

Of the 192 gas-heated houses with basements, 170 responded to the question about basement slab insulation. Thirty-six of these 170 houses reporting, or 21 percent, had insulated basement slabs. Of the 36 houses reporting insulated basement slabs, 28 have perimeter slab insulation with a median R-value of 8.5 (12 of the 28 houses reported perimeter slab insulation R-value), and 8 have full slab insulation with a median R-value of 11.

SLAB-ON-GRADE INSULATION

Slab-on-grade construction is not found in many of the 1988 survey houses. Slightly over half of the survey houses responded to this question (81 of the 126 electrically-heated houses, and 125 of the 250 gas-heated houses). Twelve percent of the 81 electrically-heated houses and 16 percent of the 125 gas-heated houses were built with a slab-on-grade.

Electrically-heated houses relied almost exclusively on full-slab insulation, and gas-heated houses on perimeter slab insulation. Nine of the 10 electrically-heated houses with a slab-on-grade have full-slab insulation with a median R-value of 5, and one electrically-heated house has R-11 perimeter insulation. Two of the 20 gas-heated houses with a slab-on-grade have full slab R-16 insulation, and 18 reported the use of perimeter slab insulation with a median R-value of 11 (6 of the 18 houses reported perimeter slab insulation R-value).

CRAWLSPACE INSULATION

Over 70 percent of the houses of each fuel type responded to this question (93 of the 126 electrically-heated houses and 178 of the 250 gas-heated houses). Thirty-seven electrically-heated houses out of the 93 reporting (40 percent) were built with some

crawlspace area. Ninety-nine gas-heated houses out of the 178 reporting (56 percent) have some crawlspace area.

All of the electrically-heated houses with crawlspaces have either the floor above the crawlspace or the crawlspace perimeter walls insulated, while 95 percent of the gas-heated houses have insulation in those areas.

About 80 percent of the houses with crawlspaces have only crawlspace perimeter wall insulation (30 of the 37 electrically-heated houses and 82 of the 99 gas-heated houses reporting crawlspaces). The median R-value of these perimeter walls for both fuel types is R-11. Five of the 37 electrically-heated houses (14 percent) versus 7 of the 99 gas-heated houses (7 percent) have insulation only in the floor above the crawlspace area; the median R-value for houses of both fuel types is 30. Two of the 37 electrically-heated houses (5 percent) have R-10 insulation in both the floor above the crawlspace and in the perimeter walls. Five of the 99 gas-heated houses (5 percent) have both the floor above the crawlspace and the perimeter walls insulated but did not report the R-values. None of the electrically-heated houses have uninsulated crawlspaces while five of the 99 gas-heated houses (5 percent) have no insulation in the floor above the crawlspace or in the perimeter walls.

WINDOWS

Builders were asked about the type of glazing used in the last electrically-heated house and the last gas-heated house they built in 1988. The builders were also asked to estimate the percentage of glazing in these houses that faces approximately south.

Glazing Area

Responses to this question were received for 96 of the 126 electrically-heated and 174 of the 250 gas-heated houses . The median glazing area for the 96 electrically-heated houses is 220 square feet, and for the 174 gas-heated houses 260 square feet.

For electrically-heated and gas-heated houses where both the glazing area and floor area are known, the median value for the ratio of the glazing area to the floor area is 10 percent for houses of both fuel types. The figure for eastern Montana houses is 8.8 percent, and for western Montana houses 10 percent.

Glazing Type

Table 12 lists the categories of glazing type and the number of electrically-heated and gas-heated houses with glazing of each type. One hundred and nine of the 126 electrically-heated houses and 226 of the 250 gas-heated houses in the survey provided a response to this question.

Standard double-glazed windows are the most commonly used window type in Montana; they were installed in 63 percent of the electrically-heated houses and 69 percent of the gas-heated houses. Double-glazed windows with low-emissivity (Low-E) coating, which are more energy-efficient than standard double-glazed, were installed in 29 percent of the electrically-heated houses and 31 percent of the gas-heated houses.

Builders of eight electrically-heated houses reported the use of windows other than double-glazed or double-glazed low-E. These "other" windows included quadra-pane windows, double-glazed low-E with Krypton/Argon gas filling, and triple glazed low-E windows.

Table 12. Glazing Type

GLAZING TYPE	ELECTRICALLY-HEATED N=109	GAS-HEATED N=226
Double-Glazed	69	156
Double-Glazed Low-E	32	69
Triple-Glazed	0	1
Other	8	0

Glazing Orientation

The median percentage of the survey houses' total glass area that is south-facing is 30 percent for electrically-heated houses, and 40 percent for gas-heated houses. For eastern houses the median percentage of south-facing glass is 50 percent, while for western houses the median percentage is 35 percent. Statewide, a median 40 percent of survey houses' glass is south-facing.

There are some differences in glazing orientation based on fuel type and location, but builders of both fuel types seem to exceed the 25 percent south glazing that would be expected if glazing was randomly oriented, and eastern builders aim more often than western builders for maximum southern exposure. Responses to this question were received from 93 of the 126 electrically-heated and 179 of the 250 gas-heated houses in the survey.

INFILTRATION MEASURES AND MECHANICAL VENTILATION

Air/vapor barriers

Air/vapor barriers (AVBs) are commonly installed in the walls of both electrically-heated and gas-heated houses to prevent the infiltration of outside air into the house or the exfiltration of moist inside air into the walls, ceilings and floors of the house. Electrically-heated houses are more likely than gas-

heated houses to have AVBs in the ceilings and floors in addition to an AVB in the walls, and eastern houses are more likely than western houses to have this same configuration.

Forty-seven of the 106 electrically-heated houses responding to this question (44 percent) had AVBs in the ceilings, walls and floors, while 46 of the 230 gas-heated houses responding (20 percent) had similar AVBs. Eastern houses were found to have AVBs in the ceilings, walls and floors 35 percent of the time (15 of 43 houses for which responses were received), and western houses 27 percent of the time (78 of 293 houses for which responses were received).

Table 13 lists the two types of AVBs included in the survey and the number of electrically-heated and gas-heated houses reporting the use of each type.

Table 13. Types of Air/Vapor Barriers

TYPE AVB	ELECTRICALLY-HEATED N=106	GAS-HEATED N=230
Walls Only	59	184
Ceilings, Walls, & Floors	47	46

Caulking of penetrations

The caulking or sealing of wiring, plumbing, and other penetrations is required to maintain the continuity of the air/vapor barrier. Gas-heated houses were sealed more often than electrically-heated houses, and eastern houses are sealed more often than western houses.

This question was answered by 94 of the 126 electrically-heated and 176 of the 250 gas-heated houses in the survey. For the electrically-heated houses, 42 of the 94 (45 percent) had all penetrations caulked. For the gas-heated houses, 100 of the 176 (57 percent) had all penetrations caulked. Of the 69 eastern survey-houses, 37 responded to this question and all 37 houses (100 percent) were caulked. For western houses, 233 of 307 houses responded to this question, and 105 of the 233 houses (45 percent) were caulked.

Table 14 shows the caulking practice used in electrically-heated and gas-heated houses.

Table 14. Caulking Practice

CAULKING PRACTICE	ELECTRICALLY-HEATED N=94	GAS-HEATED N=176
Penetrations Caulked	42	100
Penetrations Not Caulked	52	76

Mechanical Ventilation

The most common form of mechanical ventilation is an exhaust fan in the kitchen and each bathroom with no fresh air make-up ports or inlets. As Tables 15 and 16 show, exhaust fans without make-up air (or fresh air) ports are commonly used in houses of either fuel type in both eastern and western Montana houses. Eighty-three of the 108 electrically-heated houses answering this question (77 percent) and 218 of the 231 gas-heated houses answering (94 percent) have exhaust fans without make-up air ports (the survey includes a total of 126 electrically-heated and 250 gas-heated houses). Nineteen of the 108 electrically-heated

houses (18 percent) have the more advanced heat recovery ventilators, or air-to-air heat exchangers, while 3 of the 231 gas-heated houses (1 percent) have these devices.

Two types of mechanical ventilation systems allow for the entrance of fresh air into a house. These two systems are 1) heat recovery ventilators (HRVs), and 2) exhaust fans with fresh air ports or inlets. Either system is acceptable in a tightly sealed house. Only 8 percent of the 339 houses reporting statewide have fresh air inlets (22 have heat recovery ventilators and 4 have exhaust fan systems with fresh air ports). Six of the 44 eastern houses answering this question (14 percent) and 20 of the 295 western houses answering (7 percent) employ one of the two mechanical ventilation systems described above (the survey includes a total of 69 eastern and 307 western houses). Worse yet, only 4 of the 231 gas-heated houses (2 percent) have mechanical ventilation systems such as those described above; a troublingly small number given the high incidence of well-sealed gas-heated houses. The failure to provide fresh air inlets in tightly sealed houses could result in indoor air pollution and a potentially serious long-term health risk to occupants.

Table 15. Ventilation Systems by Fuel Type

VENTILATION SYSTEM TYPE	ELECTRICALLY-HEATED N=108	GAS-HEATED N=231
No Mechanical Ventilation	1	9
Exhaust Fans (No Fresh Air Ports)	83	218
Heat Recovery Ventilator	19	3
Exhaust Fans with Fresh Air Ports	3	1
Other (Exhaust Fan Based)	2	0

Table 16. Ventilation Systems by Geographic Location

VENTILATION SYSTEM TYPE	STATEWIDE N=339	EAST N=44	WEST N=295
No Mechanical Ventilation	10	4	6
Exhaust Fans (No Fresh Air Ports)	301	34	267
Heat Recovery Ventilator	22	6	16
Exhaust Fans with Fresh Air Ports	4	0	4
Other (Exhaust Fan Based)	2	0	2

OUTSIDE COMBUSTION AIR FOR FURNACE

Of the 250 gas-heated houses in the survey, 49 are located in eastern Montana. Eighteen of the 49 eastern gas-heated houses answered this question. Fifteen of the 18 (83 percent) had combustion air supplied to the furnace from outside of the house.

The survey included a total of 201 gas-heated houses in western Montana. One hundred and forty-three of the 201 houses answered this question. One hundred and forty-one of the 143 gas-heated western houses answering (99 percent) had outside air supplied to the furnace for combustion.

The fact that so few eastern houses responded to this question (37 percent) in comparison to the percentage of western houses responding (71 percent) may indicate a lack of understanding in the east with respect to this important feature.

HEATING SYSTEM

Of the 376 houses in the survey, approximately one-third were electrically-heated (126 of 376 houses). In eastern Montana, 20 of the 69 survey houses were electrically-heated (29 percent),

while in western Montana 106 of the 307 survey houses were electrically-heated (35 percent).

Most electrically-heated houses, 83 percent, have baseboard resistance heating systems, wall heaters, or both. The majority of gas-heated houses, 85 percent, have high-efficiency gas furnaces with an 80 percent or better annual fuel utilization efficiency (AFUE).

Table 17 shows the types of heating systems available and the number of houses reporting each type.

Table 17. Heating Systems

ELECTRICALLY-HEATED HOUSES N=126		GAS-HEATED HOUSES N=246	
Baseboards	85	Conventional Furnace (about 75% AFUE)	1
Wall Heaters	12	High-Efficiency (above 80% AFUE)	180
Bsbrds. & Wall Htrs.	7	Condensing Furnace (above 85% AFUE)	30
Forced Air	0	Gas-Hydronic System	35
Radiant Panels	14	Other	0
Electric-Hydronic	8		
Other	0		

Note: Four of the 250 gas-heated houses did not provide furnace type.

WOOD BURNING DEVICES

Builders were asked whether wood burning devices were installed in their houses. Statewide, 31 percent of the houses built in 1988 have wood burners. Wood burners were installed in 25 percent of eastern houses and 32 percent of western houses.

Of the 126 electrically-heated houses in the survey, 59 houses (47 percent) had a wood burner installed. Of the 250 gas-heated houses surveyed, 248 houses answered this question and 57 houses (23 percent) had a wood burning device installed. Since electricity, when compared to natural gas, is currently almost four times as expensive per delivered Btu of heat, it is not surprising that a greater percentage of electrically-heated houses have wood burning devices.

"MCS RANKING"

"MCS RANKING" OF 1988 SURVEY HOUSES

The amount of insulation that is cost-effective in a new house depends on several economic factors. The primary factors are the price of heating fuels and the incremental costs of energy-efficient components over standard components. Given that electricity is more expensive per unit of delivered heat than natural gas, the purchase of more insulation makes sound economic sense for the buyer of an electrically-heated house. DNRC has found that the MCS package of components is generally cost-effective for the buyers of electrically-heated houses built in Montana.

The survey data show that a substantial percentage of gas-heated houses are built with components normally found in electrically-heated MCS houses. Since there is currently no compelling economic reason to insulate a gas-heated house beyond the levels required by HUD standards, occupant comfort and a desire to protect oneself from unforseen future natural gas price increases may be significant in determining the amount of insulation to be installed in new houses.

Energy-efficient houses have amenities that make them more desirable than standard houses. For example, energy-efficient components such as better insulated walls and low-E glazing have, during cold weather, warmer inside surfaces which result in increased occupant comfort. Another benefit found in energy-efficient houses is the reduction of interior noise levels due to traffic noise and other sounds from outside.

For the purpose of quantifying the insulation levels installed in different types of Montana houses, DNRC has devised an "MCS Ranking" that was used to rate the components used in each house in terms of their approximation to one of three standards: "less than HUD", HUD, and MCS. The "less than HUD" level is defined as that level of construction that does not meet the Minimum Property Standards of the United States Department of Housing and Urban Development (HUD), while the HUD level is that level meeting these standards. The MCS level applies when the Northwest Power Planning Council's Model Conservation Standards are met. Using this ranking method, each house was assessed on the basis of 12 of the house's components. Three points were assigned for each component that met MCS standards, two points for each HUD component, and one point for components that did not meet HUD standards.

Responses to questions describing window glazing type and total wall R-value were weighted twice as much as the responses to the other 10 questions. The purpose of the additional weight was to account for the larger effect of window glazing type and wall R-value on a house's design heating load. A tabulation of the components, weighting, and ranking criteria is shown in Table 18. Note that to qualify for the "less than HUD" standard, component insulation levels had to be greater than or equal to R-1 and less than the HUD standard. The purpose of this requirement was to prevent unanswered questions from being ranked as "less than HUD" by the computer.

Table 18. Components and Standards Used in the "MCS Ranking"

COMPONENT	WEIGHT	LESS THAN HUD	HUD	MCS
1- Ceiling R	1	>=1	>=38	>=49
2- Wall R (Above Grade)	2	>=1	>=19	>=24[2]
3- Basement Wall R[1]	1	>=1	>=11	>=19[3]
4- Window Glazing Type	2	SNGL	DBL	DBL-Low-E
5- Air/Vapor Barrier	1	NONE	Walls	Ceiling,Wall,Floor
6- Mech. Ventilation Sys.	1	N/A	Fans	Mech. w/ Air Inlets
7- Floor R (Above Unhtd.Bsmnt)	1	>=1	>=19	>=30
8- Slab-On-Grade Perimeter R	1	N/A	<10	>=10
Full Slab R	1	N/A	<5	>=5
9- Basement Slab Perimeter R	1	N/A	<10	>=10
Full Slab R	1	N/A	<5	>=5
10-Crawlspace R (Floor,Wall)[4]	1	>=1	>=7.5	>19[2]
11-Window Area & Orientation[5]	1	N/A	N/A	<=15% Flr.& >=67% S
12-Caulked Penetrations	1	N/A	N/A	All Penetr. Caulked

[1] It was assumed that insulated basement walls in unheated basements would eventually lead to heating of the basement, so all basement walls were assessed as though the basement was heated.

[2] The MCS prescriptive path calls for R-27 above-grade walls and R-30 floors/crawlspace walls; however, the performance standard may be met with some component insulation levels reduced and others increased.

[3] MCS points were assigned to houses with R-10 or better insulation on the outside of the basement wall.

[4] Additional MCS points were assigned to houses with both the floor above the crawlspace and the perimeter walls insulated.

[5] MCS points were assigned to houses with less than 15 percent of their floor area in windows and more than 67 percent of those windows facing south.

The points assigned to each of a house's components were then totalled and divided by the summation of the weighted value of the questions answered. In this manner, a ranking was produced for each house. A house meeting the MCS standards would receive

a ranking of 3.0, a house whose every component equaled the HUD standards would have a ranking of 2.0, while a house falling below the HUD standards in every component area would receive a 1.0 ranking. Houses with components meeting different standards received fractional rankings, 2.5 for instance. The rankings of all survey houses are presented in the Table 19 where they are separated by heating-system type and geographic location.

Table 19. Overall MCS Rankings of Houses in Montana by Heating System and Geographic Location

	ELECTRIC HEAT	GAS HEAT	ALL HOUSES
WESTERN MONTANA	2.32	2.15	2.20
EASTERN MONTANA	2.33	2.19	2.23
STATEWIDE	2.32	2.16	2.21

NOTES:
1) Ranking; 1.0 = "Less Than HUD," 2.0 = HUD, 3.0 = MCS.
2) Survey houses used in the MCS Ranking; 100 of 106 electric-west, 199 of 201 gas-west, 20 of 20 electric-east, and 49 of 49 gas-east. Statewide 368 of 376.

There is virtually no difference between the ranking of houses built in eastern Montana (2.23) and western Montana (2.20). Eastern electrically-heated houses, at 2.33, rank much the same as western electrically-heated houses at 2.32. Gas-heated houses, which ranked 2.19 for the east and 2.15 for the west, also received similar rankings. This table does show, however,

that there is a substantive difference in the insulation levels and component types used in electrically-heated houses statewide, which rank 2.32, when compared to gas-heated houses statewide, which rank only 2.16. For all new houses built in 1988 the ranking is 2.21, indicating a statewide acceptance of at least some MCS components.

An "MCS Ranking" was calculated for 368 of the 376 survey houses. Adequate data was not provided for eight of the 376 houses. The groups of houses, by fuel type and geographic location, for which rankings were calculated are noted at the bottom of Table 19.

"MCS RANKING" OF LARGE AND SMALL-SCALE BUILDERS

As was found in the 1986 survey, small-scale builders built houses that are more energy-efficient than houses built by large-scale builders. Small builders are defined here as those who built fewer than five houses in the survey year of 1988. Seventy-nine small builders statewide built 172 houses whose overall MCS Ranking is 2.33, compared to 15 large builders statewide whose 196 houses have an overall MCS Ranking of only 2.10. The greatest total difference between small-scale and large-scale builders' rankings occurs in the western half of the state. Three of the 97 builders and eight of the 376 houses were excluded from the MCS Ranking due to inadequate data.

Table 20 shows the MCS Rankings for both large and small builders separated by fuel type and geographic location. The highest ranking registered is the 2.39 received by small western-electric builders, followed closely by the 2.33 received by both large and small eastern-electric builders.

Table 20. Comparison of the MCS Rankings for Large and Small Builders***

FUEL TYPE/LOCATION	LARGE BUILDER MCS RANKING* N=15**	SMALL BUILDER MCS RANKING* N=79**
Electric West	2.17 (33)	2.39 (67)
Gas West	2.06 (127)	2.29 (72)
Electric East	2.33 (12)	2.33 (8)
Gas East	2.12 (24)	2.26 (25)
Statewide	2.10 (196)	2.33 (172)

* The numbers in parenthesis after each ranking indicate the total number of houses used in the MCS Ranking calculation.

** Of the 97 builders building 376 houses, three small western builders building six electric houses did not provide enough data and were completely excluded. Additionally, one large western builder building three electric and two gas houses did not provide enough data on the two gas houses for them to be included in the rankings; the builder and his three electric houses were included.

***Ranking; 1.0 = "Less Than HUD," 2.0 = HUD, 3.0 = MCS.

COMPARISON OF 1986 AND 1988 BUILDING PRACTICE SURVEYS

One of DNRC's objectives in surveying builders is to track the level of energy-efficiency built into new houses. Repeating the survey every 2 years allows DNRC to identify changes in both the insulation levels and types of components used in Montana's new houses. To legitimately evaluate these changes and to determine whether the changes are statistically significant, the sampled builders must be asked the same questions during each survey.

However, based on the results of the 1986 survey and on conversations with builders, DNRC decided to change parts of the 1986 survey in order to get a clearer picture, in 1988, of the diversity of current building practices.

Several differences are evident when the 1986 and 1988 survey forms are compared. The single most important difference is that the 1986 survey asked builders to report the most common building practices employed for all houses built during 1986, while the 1988 survey asked builders specific questions about the last electrically-heated and the last non-electrically heated house they built in 1988. Additionally, there are differences in the formats used for 1986 and 1988 surveys as well as in the specificity of the surveys' questions.

For the purpose of comparing the 1986 and 1988 building practice surveys, the 1988 survey responses were left unweighted by the number of houses built by each builder in order to make the 1988 results comparable to the unweighted 1986 results. Further, the 1986 survey did not ask builders questions about component insulation based on the type of heating fuel used in the house. The 1988 survey did ask these questions, so the responses from the 1988 survey were combined into a single data set for comparison with the 1986 results.

Even though a comparison between fundamentally different survey data sets presents problems, some observations can be made. The most appropriate way to compare the results of the 1986 and 1988 surveys is to present the percentages of builders in each survey that equalled or exceeded a given level of insulation for each component being examined. Since HUD standards represent the minimum insulation levels usually installed in new houses in Montana, and since MCS levels of insulation are the goal for all new houses, levels of insulation approximately equal to the MCS

were chosen to compare the market penetration of MCS-like construction practice in 1986 to that in 1988.

COMPONENT INSULATION LEVELS USED IN COMPARISON OF SURVEYS: For walls, R-24 or better was chosen as the insulation level used to compare the 1986 and 1988 surveys. A typical R-24 wall would be constructed of 2X6 studs with an R-19 fiberglass batt and R-5 rigid sheathing (one inch of polystyrene). For ceilings, R-48 or better was chosen as the insulation level used in the comparison; the 1986 survey recorded the number of builders meeting or exceeding the R-48 insulation level in ceilings which necessitated the choice of R-48 for use in comparing the 1986 survey to the 1988 survey. For windows, double-glazed Low-E or better windows were chosen as the level used in the comparison because these windows most closely approximate the MCS requirements. The MCS prescriptive path, which specifies component insulation levels, need not be explicitly followed if the MCS performance standard is met. Using the slightly reduced insulation levels shown above for walls and ceilings, it is still possible to meet the MCS. The MCS performance standard can be met by increasing other component insulation levels to offset the energy-efficient performance lost when the insulation levels of some components are reduced. A comparison between the 1986 and 1988 surveys is made in Table 21.

Table 21. 1986 and 1988 Montana Builders' Surveys Compared

COMPONENT INSULATION LEVEL	1986 % BUILDERS EXCEEDING	1988 % BUILDERS EXCEEDING
WALLS - R-24 or Better	25% (E-21,W-26)	30% (E-33,W-29)
CEILINGS - R-48 or Better	19% (E-11,W-22)	23% (E-24,W-23)
WINDOWS - Dbl. Glz. Low-E or Better	41% (E-35,W-42)	50% (E-50,W-51)

NOTE: Numbers shown in parenthesis indicate, for "E," the eastern percentage and, for "W," the western percentage of builders meeting the designated component level.

WALLS: In the 1986 survey, 25 percent of the builders statewide commonly equaled or exceeded R-24 wall insulation while 30 percent exceeded this level in 1988. The largest gain in market penetration between 1986 and 1988 was experienced in eastern Montana where R-24 wall usage among builders increased from 21 percent to 33 percent. The usage of R-24 or better walls in western Montana increased by only 3 percent to 29 percent between 1986 and 1988.

CEILINGS: In the 1986 survey, 19 percent of the builders statewide commonly used R-48 or better insulation in ceilings, while in the 1988 survey 23 percent of the builders statewide equalled or exceeded R-48 in ceilings. There was virtually no increase in the number of western builders using R-48 ceilings in the two survey years (from 22 to 23 percent), but there was a

substantial increase in the number of eastern builders insulating to this level (from 11 to 24 percent).

WINDOWS: In the 1986 survey, 41 percent of the builders statewide commonly installed double-glazed Low-E or better windows, while in the 1988 survey 50 percent of the builders statewide installed double-glazed Low-E or better windows. Both eastern and western Montana registered an increase in the use of these windows with the eastern half of the state again experiencing the larger increase; eastern Montana increased from 35 to 50 percent, and western Montana from 42 to 51 percent.

CONCLUSION - 1986 VERSUS 1988 SURVEY COMPARISON: Although the 1986 and 1988 surveys are not directly comparable, it appears that for Montana as a whole, houses built in 1988 are better insulated than houses built in 1986. When the results are separated into their eastern and western subgroups, it is evident that the increase in the market penetration of energy-efficient components has occurred almost entirely in the eastern half of the state. When further comparison was made between the 1986 survey results and the 1988 survey results, it was found that eastern Montana had an average 73 percent increase in the number of builders approximating the MCS standard for walls, ceilings and windows, while western Montana had an average 13 percent increase. Montana, as a whole, experienced an average 21 percent increase in the number of builders meeting these three component insulation levels. It should be noted that the sample of eastern Montana builders, at 18, is small in relation to the total of 97 builders responding to the survey and included in the figures above.

CONCLUSIONS

Geographic location seems to have little bearing on the level of insulation incorporated into new houses by Montana's builders. Houses in eastern Montana were found to be insulated, overall, to approximately the same level as houses in the western part of the state. Of note is the fact that builders in the east tended to use insulation strategies different from those used in the west. While western builders used higher R-values in ceilings and walls, eastern builders more frequently utilized MCS-level air/vapor barriers, good sealing and caulking practices, and heat recovery ventilators.

Electrically-heated houses were found to be significantly better insulated than gas-heated houses. This is expected since the cost of electric heating is many times more expensive than the cost of gas heating. However, even the builders of gas-heated houses incorporated many energy-efficient components into their houses. Since MCS levels of energy-efficiency are not, at present, considered cost-effective for gas-heated houses, the decision to insulate gas-heated houses beyond HUD standards must be driven by other reasons. These reasons may include the desire to provide maximum occupant comfort and to protect against unforseen future fuel price increases.

The trend in insulation levels used in Montana's houses can be demonstrated by comparing the results of DNRC's 1986 and 1988 building practice surveys. The increase in the number of builders approximating the MCS standards between 1986 and 1988 has resulted in better insulated houses throughout Montana. Survey responses from western builders indicate that a minor increase in the use of energy-efficient components occurred in the west during this period. In contrast, responses from eastern builders indicate that the use of MCS-like components in the east

increased, between 1986 and 1988, to the point that new eastern houses are now as energy-efficient as new western houses.

A substantial commitment in time and money has been invested throughout Montana to improve the energy-efficiency of houses in the state. The most notable of these efforts are the demonstration projects, workshops and incentive programs funded by the Bonneville Power Administration and instituted in western Montana. These efforts have resulted in the expectation that western Montana houses should be better-insulated than eastern Montana houses. The fact that this study finds eastern and western houses to be of similar energy-efficiency is contrary to what some expected.

SURVEY OF 1988 BUILDING PRACTICES: SINGLE FAMILY HOUSES

MONTANA
DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
Lee Metcalf Building
1520 East Sixth Avenue
Helena, Montana 59620-2301

March 9, 1989

**1988 Survey of Building Practices:
Single Family Houses**

We want to know how Montanans build and insulate new houses. Everybody talks about energy conservation, but you could claim too much or too little savings from extra energy conservation unless you compare it to how houses are currently being built. To make sure we get our own analysis right, we're sending this survey to building contractors and homebuilders.

Please take a few minutes to fill out the survey. Return it in the stamped envelope by March 30, 1989. If you want a summary of the results, fill out and mail the enclosed card.

Thanks for your help.

№ 0928

SURVEY OF 1988 BUILDING PRACTICES: SINGLE FAMILY HOUSES

What is your ZIP code?_____

Please check the one that best describes you.

___I am a contractor or homebuilder who built single family houses in 1988.
___I am not a contractor or professional homebuilder, but I did build my own house in 1988.
___I am not a contractor, nor did I build my own home in 1988, so why did you send me this survey?

Number of houses you built in Montana in 1988_____

This survey is divided into two sections. The first section asks about the last electrically-heated home you built in 1988, and the second section asks about the last home you built in 1988 that wasn't heated by electricity. If you didn't build both types of homes in 1988, then only answer the section that applies to you.

ELECTRICALLY-HEATED HOMES

Number of ELECTRICALLY-HEATED single-family homes you built in Montana in 1988_____

Please fill out these questions about the last ELECTRICALLY-HEATED home you built in Montana in 1988.

Estimate the floor area of the home, including any basement area, but not garage area._____ft²

Main electric heating system type: Baseboards ____
Wall heaters ____
Forced air electric furnace ____
Radiant panels ____
Electric hydronic ____
Other (describe) _____

Was a wood burning device installed in this home? Yes____ No____

If the house has more than one type of any component (such as vaulted and flat ceilings), please check the one that best describes the component type with the largest area.

CEILING INSULATION TYPE: Batt ____ R-Value _____
Loose fill ____ R-Value _____
Other _____ R-Value _____

ABOVE-GRADE WALLS: FRAMING TYPE:
2X4, 16"oc ____
2X4 double wall ____
2x6, 16"oc ____
2X6, 24"oc ____
Other _____

CAVITY INSULATION:
Batts ____ R-Value _____
Blown-in Fiberglass ____ R-Value _____
Blown-in Cellulose ____ R-Value _____
Other _____ R-Value _____

NON-CAVITY INSULATION: (if used)
Type (blueboard, thermax, etc.) _____
R-Value or thickness_____

BASEMENT: This home has no basement ____
Full basement, under entire house ____
Full daylight basement, under entire house ____
(daylight basement means some above grade basement wall area)

Partial basement, under part of house ____
Partial daylight basement, under part of house ____
(daylight basement means some above-grade basement wall area)

Is the basement heated? Yes____ No____
Is the floor above the basement insulated? Yes____ No____
If Yes, What is the R-Value_____

Basement Walls: Are the below-grade basement walls insulated? Yes____No____
Outside Insulation R-Value_____ Inside Insulation R-Value_____

Basement Slab: Basement slab is not insulated ____
Entire basement slab is insulated ____ R-Value _____
Only perimeter of basement slab is insulated ____ R-Value _____

SLAB-ON-GRADE: This home has no slab-on-grade. ____
Slab-on-grade not insulated ____ R-Value _____
Entire slab-on-grade is insulated ____ R-Value _____
Only perimeter of slab-on-grade is insulated ____ R-Value _____

CRAWLSPACE: This home has no crawlspace. ____
Floors above crawlspace not insulated ____ R-Value _____
Floors above crawlspace insulated ____ R-Value _____
Crawlspace walls not insulated ____ R-Value _____
Crawlspace walls perimeter insulated ____ R-Value _____

WINDOWS: Square Feet of Glass _____
Type of Glazing: Double glazed ____
Double glazed Low-E ____
Triple pane ____
Other _____
About what percentage of the glass faces approximately south?_____%

INFILTRATION CONTROL: Air/Vapor barrier in walls only ____
Air/Vapor barrier in ceilings, walls, and floors ____
Other Air/Vapor barrier ____
Were wiring and other penetrations caulked or sealed? Yes____ No____

MECHANICAL VENTILATION: This home has no mechanical ventilation ____
This home has bath and/or kitchen fans that exhaust to the outside. ____
This home has a heat recovery ventilator. ____
Exhaust ventilation with make-up air ports. ____
Other mechanical ventilation system ____

How would you say this home compares to the other electrically-heated homes you built in 1988?
Better insulated ____
Less well insulated ____
About average ____

Do you have any additional comments? _____

NON-ELECTRICALLY HEATED HOMES

Number of GAS-HEATED homes you built in Montana in 1988 _____
Number of homes you built that were heated with fuel other than gas or electricity _____

Please fill out these questions about the last non-electrically -heated home you built in Montana in 1988.

Estimate the floor area of the home, including any basement area, but not garage area_____ft²

Main gas heating system type: Conventional furnace (about 75% AFUE) ____
High-efficiency furnace (above 80% AFUE) ____
Condensing furnace (above 85% AFUE) ____
Gas-hydronic system ____ AFUE, if known_____
Other (describe) _____
Is combustion air supplied directly from outside? Yes____ No_____

Was a wood burning device installed in this home? Yes____ No ____

If the house has more than one type of any component (such as vaulted and flat ceilings), please check the one that best describes the component type with the largest area.

CEILING INSULATION TYPE: Batt ____ R-Value _____
Loose fill ____ R-Value _____
Other _____ R-Value _____

ABOVE-GRADE WALLS: FRAMING TYPE:
2X4, 16"oc ____
2X4 double wall ____
2x6, 16"oc ____
2X6, 24"oc ____
Other _____

CAVITY INSULATION:
Batts ____ R-Value _____
Blown-in Fiberglass ____ R-Value _____
Blown-in Cellulose ____ R-Value _____
Other _____ R-Value _____

NON-CAVITY INSULATION: (if used)
Type (blueboard, thermax, etc.) _____
R-Value or thickness _____

BASEMENT: This home has no basement ____
Full basement, under entire house ____
Full daylight basement, under entire house ____
(daylight basement means some above grade basement wall area)

Partial basement, under part of house ____
Partial daylight basement, under part of house ____
(daylight basement means some above-grade basement wall area)

Is the basement heated? Yes____ No____
Is the floor above the basement insulated? Yes_____ No_____
If Yes, What is the R-Value _____

Basement Walls: Are the below-grade basement walls insulated? Yes____ No_____
Outside Insulation R-Value_____ Inside Insulation R-Value_____

Basement Slab: Basement slab is not insulated ____ R-Value _____
Entire basement slab is insulated ____ R-Value _____
Only perimeter of basement slab is insulated ____ R-Value _____

SLAB-ON-GRADE: This home has no slab-on-grade. ____ R-Value _____
Slab-on-grade not insulated ____ R-Value _____
Entire slab-on-grade is insulated ____ R-Value _____
Only perimeter of slab-on-grade is insulated ____ R-Value _____

CRAWLSPACE:

This home has no crawlspace. ____
Floors above crawlspace not insulated ____ R-Value _____
Floors above crawlspace insulated ____ R-Value _____
Crawlspace walls not insulated ____ R-Value _____
Crawlspace walls perimeter insulated ____ R-Value _____

WINDOWS:

Square Feet of Glass _____
Type of Glazing: Double glazed ____
Double glazed Low-E ____
Triple pane ____
Other _____
About what percentage of the glass faces approximately south?_____%

INFILTRATION CONTROL:

Air/Vapor barrier in walls only ____
Air/Vapor barrier in ceilings, walls, and floors ____
Other Air/Vapor barrier _____
Were wiring and other penetrations caulked or sealed? Yes____ No____

MECHANICAL VENTILATION:

This home has no mechanical ventilation ____
This home has bath and/or kitchen fans that exhaust to the outside. ____
This home has a heat recovery ventilator. ____
Exhaust ventilation with make-up air ports. ____
Other mechanical ventilation system _____

How would you say this home compares to the other non-electrically-heated homes you built in 1988?

Better insulated ____
Less well insulated ____
About average ____

Do you have any additional comments? _____

_____

_____

_____

_____

_____